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HEAT RECOVERY INCINERATOR-EQUIPMENT SELECTION AND PLANT
LAYOUT FOR SAFETY HUMAN ENGINEERING AND MAINTAINABILITY
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NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

Sponsored by
NAVAL FACILITIES ENGINEERING COMMAND

HEAT RECOVERY INCINERATOR-EQUIPMENT
SELECTION AND PLANT LAYOUT FOR SAFETY,
HUMAN ENGINEERING AND MAINTAINABILITY

October 1984

An investigation conducted by:
VSE Corporation
1200 Pasco Camarillo
Camarillo, CA 93010-6093

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METRIC CONVERSION FACTORS

Approximate Conversions from Metric Measures			
Symbol	When You Know	Multiply by	To Find
mm	millimeters	0.04	inches
cm	centimeters	0.4	inches
m	meters	3.3	feet
km	kilometers	1.1	miles
cm ²	square centimeters	0.16	square inches
m ²	square meters	1.2	square yards
km ²	square kilometers	0.4	square miles
ha	hectares (10,000 m ²)	2.5	acres
g	grams	0.035	ounces
kg	kilograms	2.2	pounds
t	tonnes (1,000 kg)	1.1	short tons
ml	milliliters	0.03	fluid ounces
l	liters	2.1	pints
l	liters	1.06	quarts
l	liters	0.26	gallons
m ³	cubic meters	36	cubic feet
m ³	cubic meters	1.3	cubic yards
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature

Approximate Conversions to Metric Measures			
Symbol	When You Know	Multiply by	To Find
in	inches	2.5	centimeters
ft	feet	30	centimeters
yd	yards	0.9	meters
mi	miles	1.6	kilometers
in ²	square inches	6.5	square centimeters
ft ²	square feet	0.09	square meters
yd ²	square yards	0.8	square meters
mi ²	square miles	2.6	square kilometers
acres	acres	0.4	hectares
oz	ounces	28	grams
lb	pounds	0.45	kilograms
	short tons (2,000 lb)	0.9	tonnes
teaspoon	teaspoons	5	milliliters
tablespoon	tablespoons	15	milliliters
fl oz	fluid ounces	30	milliliters
c	cup	0.24	liters
pt	pint	0.47	liters
qt	quart	0.96	liters
gal	gallon	3.8	liters
cu ft	cubic feet	0.03	cubic meters
cu yd	cubic yards	0.76	cubic meters
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature

*1 in. = 2.54 exactly. For other exact conversions and more detailed tables, see NBS Mon. Publ. 286, Units of Weights and Measures, Price \$2.25, SD Card No. C13 10-286.

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1.0 INTRODUCTION

The Naval Civil Engineering Laboratory (NCEL) Solid Waste Advanced Development Project includes formulation of design requirements and guidance for small scale Heat Recovery Incinerators (HRI) to be constructed at various naval shore activities. HRI technology for conversion of the heat value of solid waste ~~(SW)~~ to usable energy through production of industrial and domestic steam is applicable to a number of Navy and Marine Corps activities. Most of these activities require facilities with a capacity in the range of 50 tons per day, the designs of which would ^{use} ~~utilize~~ predesigned, prefabricated modular units.

While a number of this type of facility has been constructed in the private sector, and a few in the Navy, plants with maintainability problems and less than optimum safety features are common. There is a need to develop guidance for planning and designing HRIs that fully considers safety and health, human factors, and maintainability aspects of plant equipment and layouts.

1.1 Purpose and Scope. This task was to develop generic equipment choices, instrumentation requirements and locations, and general plant layouts giving equipment arrangements and spacing. Emphasis was given to safety and human engineering considerations, ~~from references 1 and 2~~ plus equipment maintenance requirements. For the purposes of this task, the modular HRI concept contained in reference 3 was used as a starting point and a 50 ton per day plant was used as the model.
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The equipment choices were, necessarily, based upon specific equipment items available from manufacturers. Selections were based upon characteristics and criteria in the references, equipment-human interface considerations, and

apparent maintainability characteristics such as accessibility. These equipment choices were used to develop alternate plant layouts for purposes of defining and illustrating safety, operator efficiency and maintenance design requirements. The control and instrumentation review was restricted to that required for safety and human factors. It is not intended to be inclusive for plant operations. In addition to basic HRI equipment and instruments, attention was given to certain personnel safety and fire protection equipment in the plant for purposes of location.

This report and the drawings included can assist facility planners, designers, and reviewers in ensuring that HRIs incorporate features and equipment which provide a safe, human-oriented, and efficiently maintained plant.

2.0 OVERVIEW OF CRITERIA

In addition to the material in references 1 and 2 concerning safety and human engineering concerns, there are Government documents that provide guidance and criteria applicable to the design of HRIs. Some of these documents are specifically invoked in contracts for system, equipment, and facility design. The following paragraphs provide references, examples, and an overview of the criteria that guided this task and that are applicable to specific HRI designs. There is, of course, considerable interrelation and overlap between safety, human engineering and maintainability considerations. The distinction is made for convenience.

2.1 Safety and Health. Safety and health concerns are important in an HRI as in all industrial facilities. However, some of the HRI concerns are not normally encountered at naval activities. These more unique concerns include potential health and safety hazards to individuals hand-sorting the conglomerate of solid waste, the potential of dangerous substances and inflammable or explosive items being encountered, hazards of equipment dumping and moving the waste, dangers inherent in pit and crane-to-hopper operations, and hazards of people working around high temperature incinerators. The basic guidance is contained in the publications of the Occupational Safety and Health Administration (OSHA), particularly reference 4. Naval Facilities Engineering Command (NAVFAC) Instruction 11012.136B, Facilities Design Safety and Health Requirements, implements OSHA for the design of naval facilities.

Safety criteria and features for an HRI are those normally practiced in good designs. They must include protection and safeguards for the equipment as well as the people. For this report, fire protection is included as a

safety concern. References 5 and 6 are applicable to fire protection features. The following are examples of HRI design safety considerations. The specifics required for implementation of these criteria are addressed in sections 3.0 and 4.0.

a. Receiving and Storage Area

- Provide for controlled and safe vehicle and personnel traffic patterns.
- Provide facilities for efficient washdown and cleaning of the facility.
- Design for exclusion/control of rodents.
- Provide method for sorters to segregate hazardous items.
- Provide emergency shower/eyewash facility.
- Provide measures to prevent front-end loader and personnel from driving/falling into the pit. Also, provide personnel access into the pit.

b. Crane

- Ensure the crane and clamshell is equipped with an audio warning system, automatic travel limit switches/stops, manual emergency stop switch, and high visibility paint as a visual warning.

c. Mechanical Equipment Area

- Provide dual exits.
- Provide personnel guards on moving equipment.
- Use signs and/or color coding for "hot" and hazardous areas.
- Provide handrails and barriers.

- Ensure operator walkways are clear, overhead clearances are provided, and stairs and ladders are in accordance with safety criteria.
- Minimize "blind spots", protrusions, and obstructions.

d. Conveyors

- Provide safety guards around moving parts, emergency stop switch, and automatic cut-off for jams.
- Designate "caution" area around conveyor and quench tank.

e. Fire Protection

- Provide fire hose stations and fire alarm boxes at critical locations such as near the pit, hopper-feed ram, and hazardous material storage.

f. General

- Provide adequate restroom facilities.
- Provide drinking fountains.

2.2 Human Engineering. In accordance with Department of Defense policy, human engineering is to be applied to designs such as an HRI to the extent it is cost effective. The purposes are to improve overall efficiency, increase reliability, and minimize skill and training requirements. The objective is to gain the optimum from the man-equipment interface to decrease life cycle costs. The basic references are:

Military Standard MIL-STD-1472
Human Engineering Design Criteria for Military
Systems, Equipment and Facilities

Military Specification MIL-H-46855
Human Engineering Requirements for
Military Systems, Equipment and Facilities

The latter document may be invoked in facility design contracts to the extent required by the particular project.

Examples of the more basic criteria applicable to the HRI are:

- Ensure all operator controls are located and designed for practical reach, height, and visual limits.
- Where practical, provide for line of sight between operators and dynamic functions.
- Separate controls that may be confused with each other and provide clear labeling.
- Provide communications method between mechanical area control station, crane operator, and tipping floor.
- In addition to general building illumination, provide specific lighting where operators must work in darkened areas, read instruments and gages, operate controls, etc.
- Consider distances and operator reaction times for normal and emergency operation tasks.

2.3 Maintainability. Maintainability standards are established by the Department of Defense as one of the requirements which must be considered in the system engineering effort and in determining the effectiveness of the system. As a prime factor, it must be integrated with other design criteria in the proper relationship. It is a particularly important factor in an HRI, since the activity establishes a dependency for disposal of solid waste and production of steam. Also, a prime reason for having an HRI is the economic benefits of waste disposal and reduction in conventional fuel usage, so an economically maintained and reliable plant is necessary to achieving these economies.

Appropriate consideration of maintainability design criteria shall be reflected in the design concept review, item selection, design reviews and design tradeoffs. The basic reference is:

Military Standard MIL-STD-470

Maintainability Program Requirements (For Systems and Equipments)

Military specification MIL-M-24365 is applicable to ship systems, but the philosophy is applicable to shore facilities.

The following are some of the maintainability design guidelines which should be considered in the design of a HRI.

- Provide adequate accessibility, workspace, and work clearance for recurring maintenance, repair, and overhaul of the equipment, as well as for the conduct of operations in both normal and emergency situations.
- Provide for interchangeability of like components, materials and parts within the equipment.
- Limit the number and variety of tools, accessories, and support equipment.
- Reduce the need for and frequency of design-dictated maintenance by using fail-safe features on the SW ram feeder, the crane and grapple system, the ash transfer rams, the ash removal conveyor, and other items of equipment. Use components which require little or no recurring maintenance and have tolerances which allow for use and wear throughout the life cycle.
- Reduce maintenance downtime by designing for rapid and positive detection of malfunction or degradation, rapid and complete

preparation to begin maintenance and localization of malfunctions to the repair level for which skills, spaces, and test equipment are planned.

- Reduce design-dictated maintenance support costs by limiting the need for specialized maintenance tools and support equipment, the need for factory maintenance, and the need for extensive maintenance technical data.
- Reduce the potential for maintenance error by designing to eliminate the possibility of incorrect connection/assembly/installation, to eliminate dirty, awkward, and tedious job elements and to eliminate ambiguity in maintenance labeling, coding, and technical data.

3.0 EQUIPMENT SELECTION

The following provides discussion of generic equipment for use in this study. The choices were made from information from manufacturers' data available within the scope of this task. One of the constraints was that manufacturers of modular HRI equipment will provide specifics only when dealing with a specific, potential site and potential customer. Another constraining factor is that much of the design information is considered proprietary and is restricted because of competition.

Many of the requirements for implementing safety, human engineering, and maintainability criteria can be included in procurement and construction specifications utilizing extracts from documents referenced in section 2.0. While certain features and characteristics are mentioned in the following, there is no substitute to preparing a Guide Specification for an HRI that covers a range of plant capacities.

3.1 Front-End Loader. For enclosed areas with concrete floors, skid-steer loaders with the following characteristics have proven safe and efficient. This type of loader is in use in numerous solid waste handling plants. The more prominent manufacturers are J.I. Case Company and Clark Equipment Company. Required characteristics are:

- single, diesel engine
- solid rubber tires
- hand control levers controlling power, speed, direction, etc.
- operator protective cage
- spark arrestor

3.2 Crane. Two types of cranes may be used in the HRI with the choice depending upon building design and plant layout. As shown on figure 1, a side-wall traveling crane may be used to advantage when the pit parallels the building wall. In the plant layout of figure 2, a single girder under running trolley crane is depicted. Both may be procured with the safety features mentioned in paragraph 2.1.

The sidewall crane with a fixed boom is of simple design and is considered reliable with minimum maintenance requirements. This type requires a supporting structure on only one side of the pit leaving the other side free of obstructions. The sidewall crane is considered particularly suitable and reliable for lighter loads of 1 to 5 tons and continuous operation.

The single girder trolley crane is a design that has been in widespread use for many years. No innovative designs have been able to compete. It is constructed of standard steel shapes, moving parts are simple and exposed for maintenance and inspection, the design is adaptable to many physical plants, and the construction is rugged and reliable. Both cranes are designed with complete accessibility for maintenance and repair, replaceable components, and safety features.

3.2.1 Crane Grapple. Several types of clamshell buckets and grapples were reviewed. The type recommended is the "orange peel" grapple with an electro-hydraulic drive unit. It is a reliable unit of proven design and is particularly efficient in handling solid waste. Harnischfeger Corporation, P&H cranes, offers an electro-hydraulic orange peel grapple as one option for their refuse handling cranes. Morgan Engineering of AMCA International Corporation offers an electro-hydraulic driven orange peel grapple of German manufacture that is also specifically designed for solid waste handling.

The grabbing arms may be set for complete or partial closure and the grapple has a compressing effect on the material so that the carrying capacity can be more fully utilized. The electro-hydraulic drive has an advantage over the traditional cable-pulley design in minimizing downtime since cable fouling is eliminated.

3.3 Modular Incinerator. A modular, starved air, two-stage incinerator was specified in reference 3. Eight manufacturers' brochures were reviewed in the context of physical and performance characteristics contained in references 2 and 3. A number of manufacturers design and produce units very similar in configuration; with vertically "stacked" dual combustion chambers and a side-positioned heat exchanger parallel to the combustion chambers. The unit chosen for use in this study to develop and illustrate safety and maintainability criteria is a design in relatively widespread use. It is a well configured design with flexibility in combining multiple units or operating two incinerators for each heat exchanger. Where possible, dynamic equipment is placed so that repair and replacement is easy. The equipment configuration and spacing better lend themselves to meeting safety, human engineering, and maintainability criteria. The design allows a choice in method of SW feed, placement of the ash conveyor, and type of boiler specified. It readily adapts to alternative plant configurations as discussed in section 4.0.

The design selected may be specified, and competitively procured, with all of the features recommended in this report and references 1, 2 and 3. Major components are discussed below. The features mentioned are standard with several manufacturers and differ only in proprietary characteristics.

3.3.1. Feeder Ram. The ram is hydraulically operated with an automatic sequence backed up by manual controls for use in case of problems and for

testing. Safety and operational features that should be considered when specifications are prepared are:

- Double guillotine type door.
- Automatic water spray to prevent fire in the hopper.
- Fireproof hydraulic fluid.
- Automatic shutoff in the event of jamming and excessive hydraulic pressure to safeguard the ram and loading door.
- Manual override controls.
- Highest quality materials to increase life and reduce frequency of repair.
- Replaceable components to reduce downtime and decrease factory level repair.

3.3.2 Primary Combustion Chamber. This unit should incorporate the following features for safety and maintainability:

- A quench system to control over temperature conditions.
- A full rear-end door for easy access.
- External air port cleanout plugs to allow uninterrupted operation.
- Self-cleaning sight ports for viewing loading and ash drop areas.

3.3.3 Stoker Cylinder and Grates. The hydraulically operated stoker should be locally repairable to the extent practicable, contain a fail-safe feature to prevent damage to the ram and grate mechanism, and have a cylinder that is protected from heat and ash.

3.3.4 Secondary Combustion Chamber. Specification features that should be considered are:

- Replaceable as a unit.
- Positive, integrated automated dump stack.

3.3.5 Air Control Damper. Automatic dampers control the secondary combustion chamber venting between the boiler and dump stack. The following features should be specified:

- Automatic operation when there is a power failure or excessive steam buildup.
- Manual override controls.
- Indicator to show position and proper operation in open and closed position.
- Be easily accessible and replaceable as a unit.

3.4 Boiler. Probably more than any other component, the boiler specifications are dictated by site-specific conditions of the steam requirements and solid waste characteristics. The generic description is a water-tube type boiler certifiable under UL and ASME standards meeting the applicable provisions of NAVFAC Guide Specification NFGS-15631. These standards will ensure the provision of required safety, and in large part, maintainability requirements. While various specific boilers can be provided by manufacturers of modular HRI equipment, a design with vertical tube construction is recommended. This configuration appears to be more efficient for maintenance and repair than a horizontal tube configuration which requires large area clearance for removal of tubes. Vertical clearance is available in the design for an I-beam to support a chainfall assembly to remove the tube nest. Standard fail-safe features for high and low water levels, steam pressure and temperature will be provided.

3.4.1 Induced Draft (I.D.) Fan. As an integral component of the boiler, the I.D. fan will be covered by similar standard specifications. It should contain the usual features of overload protection, ease of recurring maintenance, be easily accessible and replaceable as a unit.

3.4.2 Boiler Feedwater Equipment. The feedwater system design and specifications are dependent upon boiler parameters, condensate return if any, local water conditions, etc. The system will consist of deaerating/storage tank, water softener if required, chemical feed injection system, and feedwater and makeup water pumps. There are numerous government and industry specifications and standards that cover each item of equipment which contain required safety and maintainability provisions. The primary concern of this study is in the efficient location of the system and in operator safety. These aspects are addressed in section 4.0.

3.5 Ash Disposal Equipment. The components include the ash quench tank, ash conveyor, and ash collection container. HRI equipment manufacturers can provide wet or dry systems with various conveyor configurations. The ash container is strictly a local determination. Configuration, location, and spacing aspects are covered in section 4.0. The equipment should have the following characteristics.

3.5.1 Ash Quench Tank. It should provide a positive water seal between the incinerator and tank, have automatic high and low water level controls, have provisions for draining and efficient cleaning and maintenance, and be constructed for long life with reliable corrosion preventive materials and coating.

3.5.2 Ash Conveyor. The conveyor should have the following features:

- Drag chain design with return chain going under the conveyor to prevent overhead interference.

- Backhoe type scoop system designed to prevent wire and small metal pieces from jamming the system.
- An enclosed design with access covers for maintenance and repair.
- Fail-safe features to prevent damage to scoops, chains, and the drive system.
- Designed to dewater the ash as it moves from quench tank to collection containers.
- External chain adjustment device with easy accessibility.

4.0 HRI PLANT LAYOUT AND DESIGN FEATURES

A number of features of a modular HRI plant have been developed and specified in references 2 and 3. Examples include the solid waste pit holding a three-day supply, the crane for feeding incinerator hoppers, area of the tipping floor, and use of an ash quench tank. This section takes the specified features, and the equipment selected in section 3.0, and investigates the best plant layout, design features, and equipment location to meet the safety, human engineering and maintainability criteria discussed in section 2.0. In addition, controls and instruments needed to meet the three categories of criteria are examined and located in context of the equipment layout.

4.1 General Plant Configurations. Two basic plant configurations were studied. The major difference is location of the SW pit relative to the incinerator hoppers. One is a layout similar to the figure in reference 3 with the pit offset to the side of the incinerators. Figure 1 provides this floor plan. The other configuration places the pit directly in front of the incinerator hoppers, between the HRI equipment and the tipping floor. Figure 2 shows this layout. For purposes of illustration in this study, the offset pit configuration (figure 1) was selected because of the following advantages:

- A wall-mounted crane can be used to advantage in this layout, leaving the pit opening next to the tipping floor free of obstructions.
- The layout lends itself to an efficient external road pattern with delivery truck access and ash removal access on the same side of the plant.

- The layout provides an efficient method for loading the hoppers with the front-end loader when the crane is out of operation.

The layout of figure 2 has been used in plants, such as Norfolk Naval Shipyard, Portsmouth, VA, and also offers certain advantages:

- This layout is better for providing a straight-through delivery truck traffic pattern.
- Crane travel distances are less for feeding hoppers.

The applications of safety, human engineering and maintainability criteria in this report are equally applicable to either, or any other similar, plant configuration. Consequently, recommendations are made in specific features, spacing, dimensions, relative locations, and design concerns rather than in overall plant layout which may be dictated by site considerations.

4.2 Solid Waste Receiving and Storage Area. The area of the tipping floor is given in reference 2 as 4500 square feet (ft²) and the volume of the SW pit as 30,000 cubic feet. The dimensions to meet these requirements are discretionary to a degree and will be determined by site conditions. For illustration purposes, figure 1 establishes dimensions of approximately 100 feet by 45 feet for the tipping floor, excluding the truck lane, and 80 x 25 x 15 feet for the pit. For implementation of the criteria in section 2.0, the following spacing, facilities, and design items are recommended:

- Provide a drive-through truck lane of a minimum width of 14 feet to accommodate delivery trucks for efficient backing for unloading.
- Restrict SW delivery trucks to one-way traffic. Provide "entrance," "exit," "do not enter," and "sound horn" signs at the appropriate truck doors.

- Mark traffic areas on the tipping floor with high visibility paint or tape to guide truck drivers, front-end loader operator and sorters. Example markings are shown on figure 1. Restrict backing of trucks to area 8 to 10 feet from walls.
- Provide a warning system for the front-end loader operator to prevent driving into the pit. The following are methods that may be considered:
 - Warning signs suspended from the ceiling, near eye level, to restrict approach distance.
 - Flexible barrier suspended from ceiling, of plastic strips, lightweight chain or similar, as a positive warning device.
 - An incline in the floor in front of the pit that would not restrict the movement of SW, but would warn the operator to stop.
 - An imbedded sensor system in the floor so the weight of the loader initiates an audio alarm and/or a visual (flashing light) alarm in view of the operator.
- Provide fencing and gates on either side of the pit to prevent incidental foot traffic into pit - crane operating area. Mark each gate with "CAUTION - Crane Operating Area" signs. The space between the pit and hopper area should be wide enough to permit the front-end loader access to the hoppers; given as 10 feet on figure 1.
- Provide personnel barriers, such as guardrails, on the sides and back of the pit, and access ladders into the pit. See

figure 1. Guardrails must be 42 inches high in accordance with paragraph 1910.23 of reference 4.

- The space behind the pit should allow for maintenance personnel access to the pit ladders and the crane structure; a space of 4 to 5 feet.
- Provide an enclosed container outside the tipping floor for rapid segregation and storage of hazardous and highly flammable items such as chemical containers, pressurized containers, and explodable/incendiary items.
- Provide an emergency shower/eyewash facility at a location quickly accessible to floor personnel. See figure 1.
- Provide fire hose stations at locations where fire is most potential. Example locations are shown near the pit and hazardous material storage container on figure 1.
- Provide fire alarm boxes at locations quickly accessible to plant operator and sorters as shown in figure 1.

4.3 Equipment Location and Spacing. The modular HRI equipment selected for this study establishes certain location and spacing parameters for the plant, such as:

- A two-level mechanical area is required.
- The location of the boiler in relation to the secondary combustion chamber is dictated to a large degree.
- The location of gas stacks is established by the design.
- The incinerator-hopper and incinerator-ash quench tank interfaces are dictated.

On the other hand, certain locations and spacings are discretionary:

- Elevations can be varied within practical limits.

- The distance between the incinerator and boiler can be varied. A minimum distance of 6 feet is recommended.
- The location of the SW pit can be varied as illustrated in figures 1 and 2. The location of the crane is, then, established.
- Orientation of ash conveyors is discretionary.
- Location of the boiler feedwater equipment and other auxiliary equipment is discretionary within practical limits.

The location and orientation of the HRI equipment in relation to the tipping floor and SW pit are discussed in paragraph 4.1. The following paragraphs discuss arrangement and spacing of the mechanical equipment. Figures 3, 4, and 5 illustrate the arrangement.

4.3.1 Upper Level Mechanical Floor. This level contains the secondary combustion chambers, boilers, and control stations. The overall configuration and, in part, dimensions are dictated by the HRI equipment design. Figure 3 is a plan of this floor showing recommended minimum spacing between and around equipment units for safety, operator efficiency, and good access for maintenance. A minimum of 3 feet for walkways is recommended, which establishes the periphery of this floor. The other controlling dimensions on this level are the space between boiler and secondary chamber, 6 feet, and between secondary chambers of the two units, 10 feet.

Dual stairways are provided to the hopper area on one end and the lower level mechanical room on the opposite end for safety under emergency exit conditions and for operator efficiency in patrolling the plant. Reference 4 contains specifications for designers such as minimum stair widths (22 inches), minimum landing dimensions (22 x 30 inches) and stair angle (50° maximum). Guardrails are provided on the three open sides (minimum height of 42 inches).

The HRI control station is centrally located for operator watchstanding and for access to each unit and the lower level. Travel times for inspection and operation are minimized. The crane operator's control station is located with a clear view of the pit, hoppers and tipping floor, and quick access to the HRI control station. The crane operator also has rapid access to the lower level hopper area.

The floor layout allows adequate room for inspection, maintenance, repair and replacement of dynamic equipment such as air damper and I.D. fan. Vertical clearance, shown on figure 5, is sufficient for removal of boiler tube nests, as mentioned in paragraph 3.4.

4.3.2 Lower Level Mechanical Room. This level contains the primary combustion chambers, boiler feedwater system, auxiliary mechanical equipment such as air compressor, office, toilet, shop and parts storage, and other areas required to be enclosed. The layout and certain dimensions are shown on figure 4. Space does not seem to be a problem on this level, since overall building dimensions are set by upper level equipment and other factors. End-to-end dimensions of this room are controlled by equipment dimensions from hopper to primary combustion chamber to quench tank-conveyor interface. The only safety related dimension discretionary in this direction is the space between the exterior wall and quench tank structure. A minimum of 3 feet should be provided. In the other direction, the distance between combustion chambers can be controlling. A minimum distance of 5 feet is shown on figure 4. The other dimensions shown are illustrative only and are discretionary to meet site specific requirements.

Exits are provided at either end of the room, one to the hopper area and dual exits to the exterior conveyor-ash collection area. A ceiling height of 13 feet provides sufficient overhead clearance.

The boiler feedwater system room is accessible from the inside and has double doors to the exterior for movement of equipment and delivery of chemicals.

Access to the ash quench tank is obtained from this level.

CO fire extinguishers and a fire alarm box should be provided in this room. For ventilation, fans in the exterior wall may be required.

4.3.3 Hopper Area. This area contains the incinerator hoppers - feed ram mechanism, space for crane - grapple maintenance, and space for the front-end loader to operate when required. A 13-foot clearance is provided between the hoppers and building wall. With the layout of figure 1, the grapple may be lowered to the floor for repair. A 20-foot X 24-foot space is available between the pit and hopper to place nonburnable items from the pit for disposal. The items can be moved to nonburnable material collection points on the tipping floor by the loader. A fire hose station and alarm box should be located near the hoppers.

4.3.4 Ash Disposal Area. The ash quench tank location and size are dictated by the primary combustion chamber design. The ash conveyor for most modular designs can be oriented in-line with the unit or perpendicular. For the two-unit plant with the layout of figure 1, individual, in-line conveyors are depicted. The ash conveyors and ash collection containers are shown outside the building. Only in very cold climates is it necessary to enclose this area.

The quench tank pit will be protected by guardrails and partially covered with removable floor grating. Required dimensions to ensure safety and maintenance access are similar to other equipment; 3 foot clearance where people must walk, a minimum 7-foot overhead clearance, and room to remove water level controls for repair.

4.3.5 Environmental Pollution Control Equipment. Some plants, depending upon waste output conditions and local regulations, will need air pollution control equipment. The requirement and types of equipment are discussed briefly in references 2 and 3. In the layout shown in figures 1, 3, 4, and 5; there is considerable flexibility to include such equipment.

- The lower level mechanical room has considerable space for auxiliary equipment.
- The position of the boiler relative to the incinerator can be changed making more room in between units in both horizontal directions.
- The upper level mechanical floor can be extended over the quench tanks, office and, by moving the deaerator tank to the lower level, over the feedwater room.
- There is overhead clearance above the upper level floor equipment for installations that fit an overhead location.

4.4 Controls and Instrumentation. The following concerns controls and instruments necessary for safety and the human factor and is not intended to be inclusive for plant operations. For the plant layout in figure 1 or figure 2, two separate control stations are recommended; one main station for the HRI equipment and one for the crane operator. Both are located on the upper level mechanical equipment floor. There is line of sight between operators. In addition, certain local controls and instruments are recommended for safety and efficient operations.

4.4.1 HRI Control Station. As shown in figure 1, the main control panel is located between the two units and may be enclosed in a booth. The location

provides line of sight to each boiler and is central for access to the hopper-ram area, the lower mechanical room, and the ash conveyor-quench tank area. The location minimizes the time to return to central control from other locations and to reach local emergency controls.

HRI equipment manufacturers will design and provide the control and instrument panel for the modular plant. For safety and effective operator-equipment interface, project specifications should ensure the following are included:

a. Controls:

- manual override controls for entire HRI equipment sequence
- manual dump stack open-close control
- auxiliary fuel supply control
- induced draft fan on-off control
- conveyor on-off control
- boiler feedwater supply control

b. Instrumentation:

- primary chamber temperature and pressure
- undergrate and overfire air pressure
- auxiliary fuel pressure
- secondary chamber temperature and pressure
- boiler feedwater pressure
- boiler feedwater level indicator
- deaerating tank water level indicator
- chemical feed indicator
- quench tank water level indicator
- ash transfer ram hydraulic cycle indicator
- feeder ram hydraulic cycle indicator

4.4.2 Crane Control Station. This station is located at the corner of the upper mechanical floor adjacent to the hoppers and SW pit. The operator requires a clear view of the pit, each hopper and the tipping floor. If necessary, the operator can communicate with loader operator and sorters. He has quick access to the lower level near the hopper-rams. If needed, he can quickly relieve the HRI operator who is a few feet away.

In addition to complete crane operational controls, the following should be provided for safety and operator efficiency:

- Feeder ram on-off control
- Feeder ram hydraulic cycle indicator

4.4.3 Local Controls and Instruments. Two categories of controls and instruments are needed in a number of locations; stop-start controls and certain local instruments for redundancy and "spot" information. The local control is absolutely required for safety on most dynamic equipment. Local instruments provide a backup system when remote instruments fail, provide the operator information when he is at the equipment, and provide a check on remote instrument readings. The following are required:

a. Local Controls

- Crane: start-stop control located on lower floor for quick reaction access
- Hopper-feed ram: start-stop control immediately adjacent to the hopper
- Dump stack: manual open-close control for the damper at the stack
- Stoker: start-stop control adjacent to sight port
- Incinerator: auxiliary fuel supply on-off control

- Boiler: steam supply and feedwater supply valves
- I.D. fan: on-off control
- Quench tank: water supply on-off valve
- Conveyor: start-stop control
- Boiler feedwater system: all controls necessary to operate the system from the feedwater room including pump start-stop, input and output water valves, chemical system on-off, and deaerator tank fill valve

b. Local Instruments

- Incinerator: temperature and pressure
 auxiliary fuel pressure
 compressed air pressure
 dump stack damper position indicator
- Boiler: steam temperature and pressure
 hot gas temperature and pressure
 feed water pressure
 water level indicator
- Ash removal: ash transfer ram hydraulic pressure
 ash transfer ram jam indicator
 quench tank water level indicator
 conveyor jam indicator
- Feedwater system: pump discharge pressures
 deaerating tank water level indicator
 chemical feed indicators
- Feeder ram: cycle indicator
 hydraulic pressure

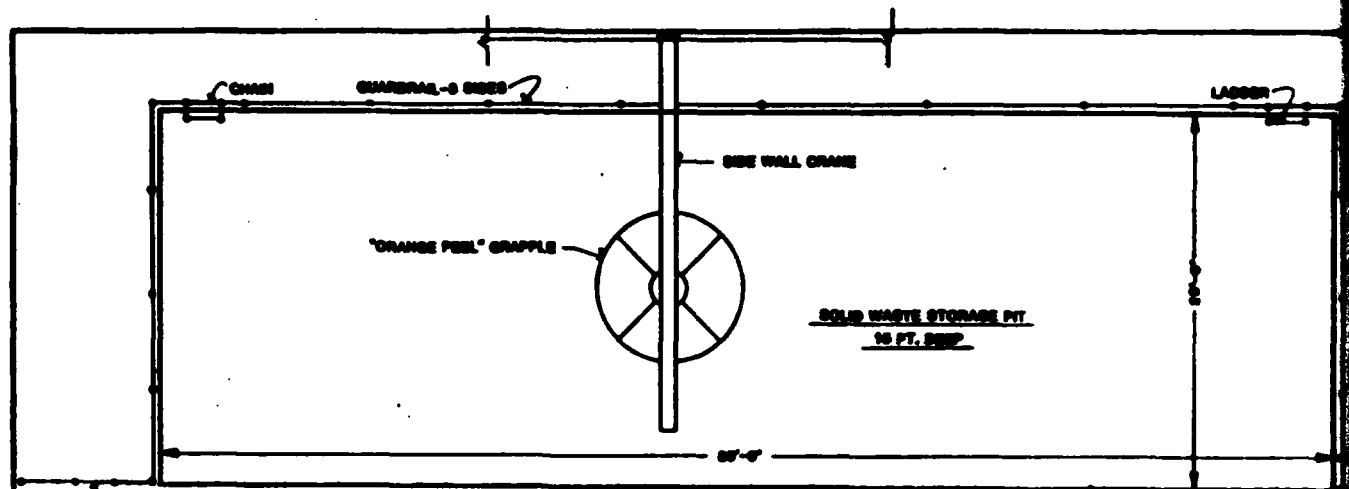
5.0 CONCLUSIONS

The following basic conclusions resulted from this study:

- A safe, efficient HRI facility incorporating sound human engineering and maintainability features can be designed and specified using established criteria and incorporating commercially available equipment and components.
- The requirement to incorporate applicable criteria from OSHA Standards, Military Standard MIL-STD-470, and Military Specification MIL-H-46855 in the design should be included in design contracts.
- Full use should be made of applicable nongovernment standards covering safety and maintainability in the HRI construction specifications. Examples are ASTM, ANSI, ASME, and UL standards.
- Construction Guide Specification and definitive drawings for modular HRIs should incorporate appropriate material from this report.

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1. NCEL CR 82.033, Safety and Human Factors Engineering Analysis, Heat Recovery Incinerator Installation, September 1982, VSE Corp.
2. Heat Recovery Incinerator, Project Planning and Design Guidelines and Checklist (Proposed), March 1983, VSE Corp.
3. NCEL TM54-82-10, Heat Recovery Incinerator Facility: 50 TPD Design Concept Using Packaged Controlled Air Combustion Technology, June 1982.
4. OSHA Safety and Health Standards (29 CFR 1910), General Industry, Revised March 1983.
5. NAVFAC Design Manual DM-8, Fire Protection Engineering.
6. NAVFAC Design Manual DM-3, Mechanical Engineering.



GATE
EMERGENCY
SHOWER

⊗ FIRE HOSE STATION
Ⓛ FIRE ALARM BOX

FIRE HOSE

STEAM HOSE

TIPPING FLOOR
4,800 SQ. FT. (LESS TRUCK LANE)

ENCLOSED
HAZARDOUS
MATERIAL
STORAGE

8'-0"
TRUCK LANE

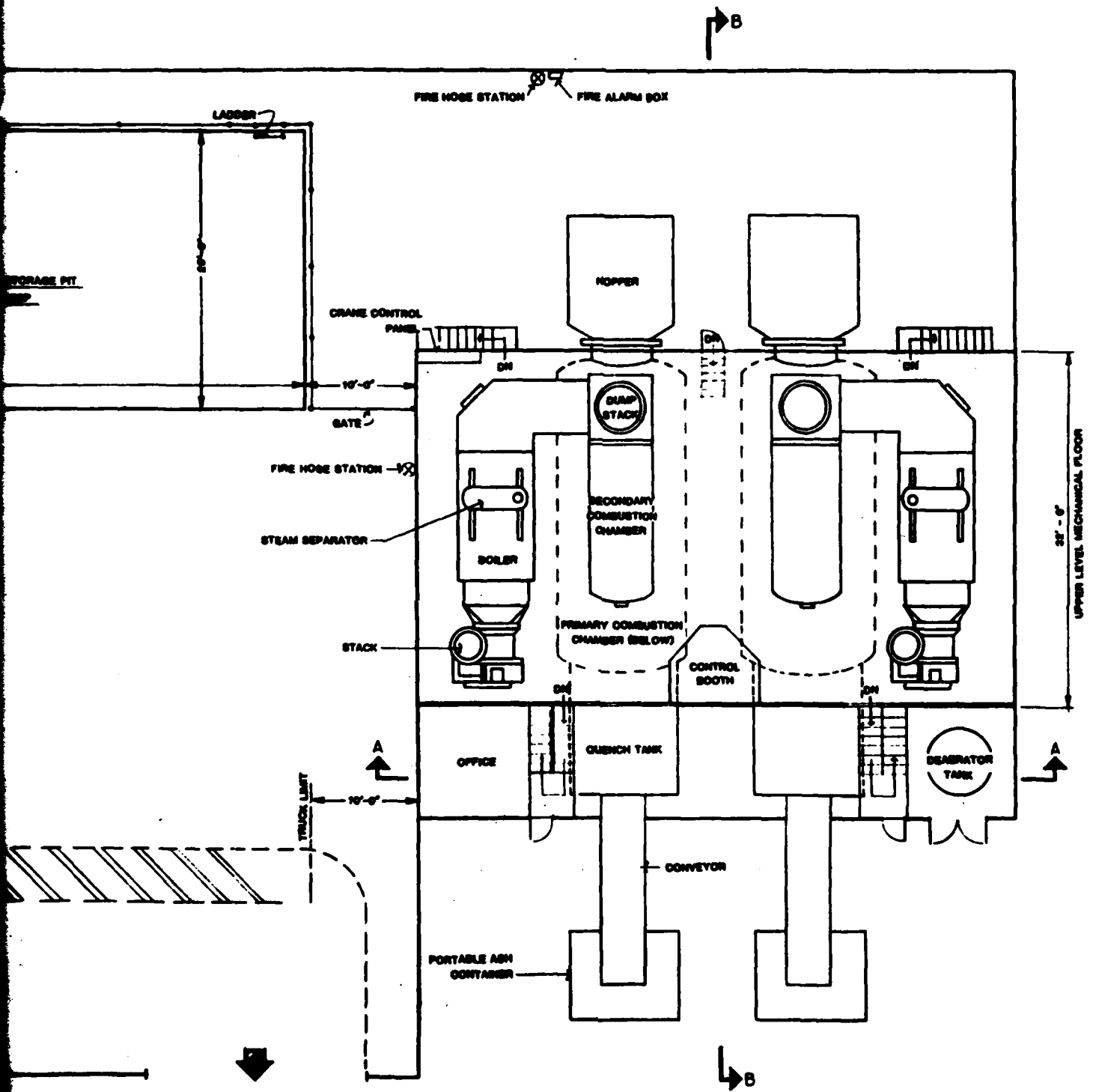
TRUCK BACKING GUIDE

STOP FRONT WHEELS HERE

TRUCK LANE

TRUCK LANE





VSE CORPORATION OAKLAND, CA.
HEAT RECOVERY INCINERATOR
FIGURE 1
PLANT LAYOUT

9/83

TRUCK ENTRY



TIPPING FLOOR

SOLID WASTE STORAGE PIT

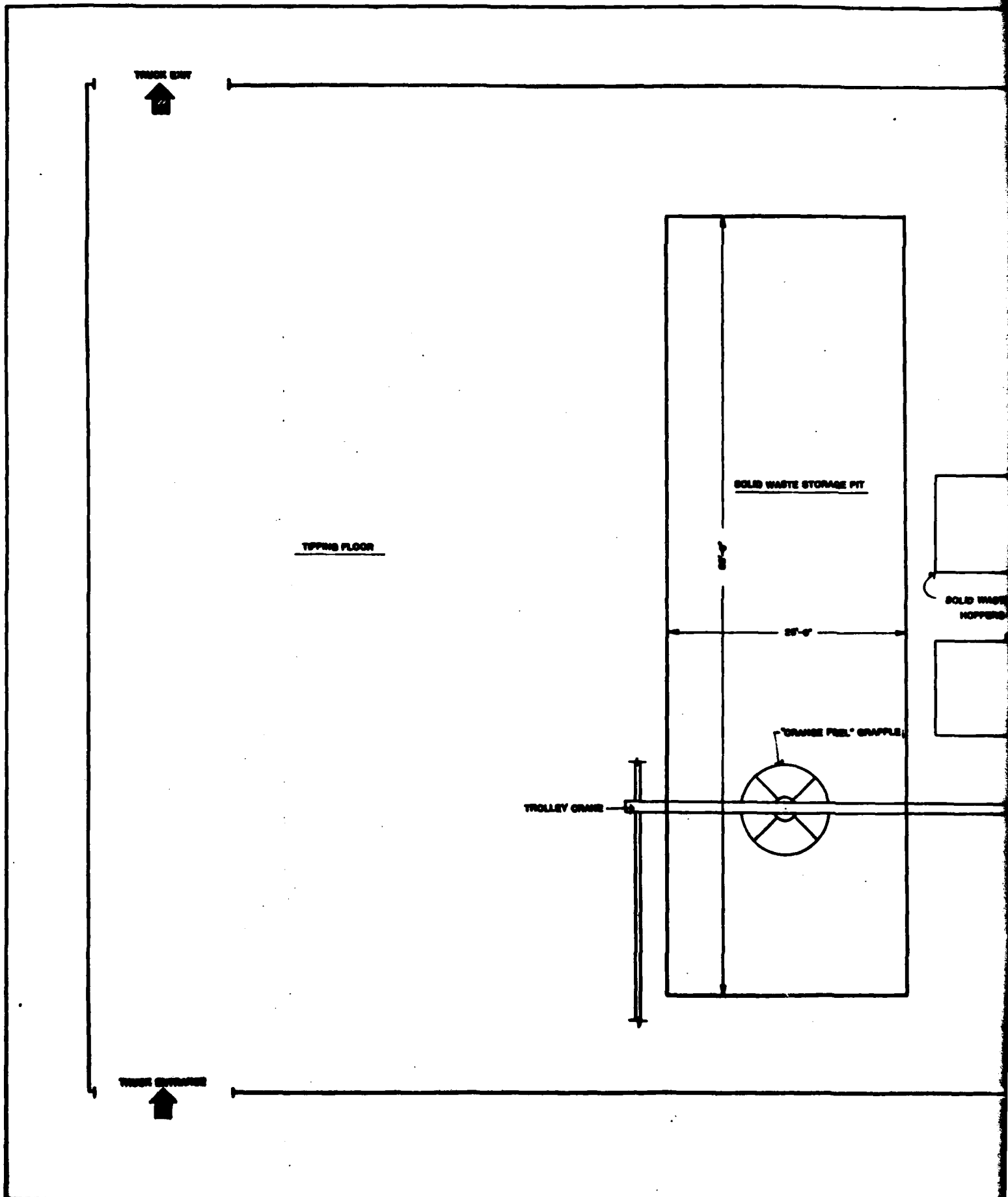
20'-0"

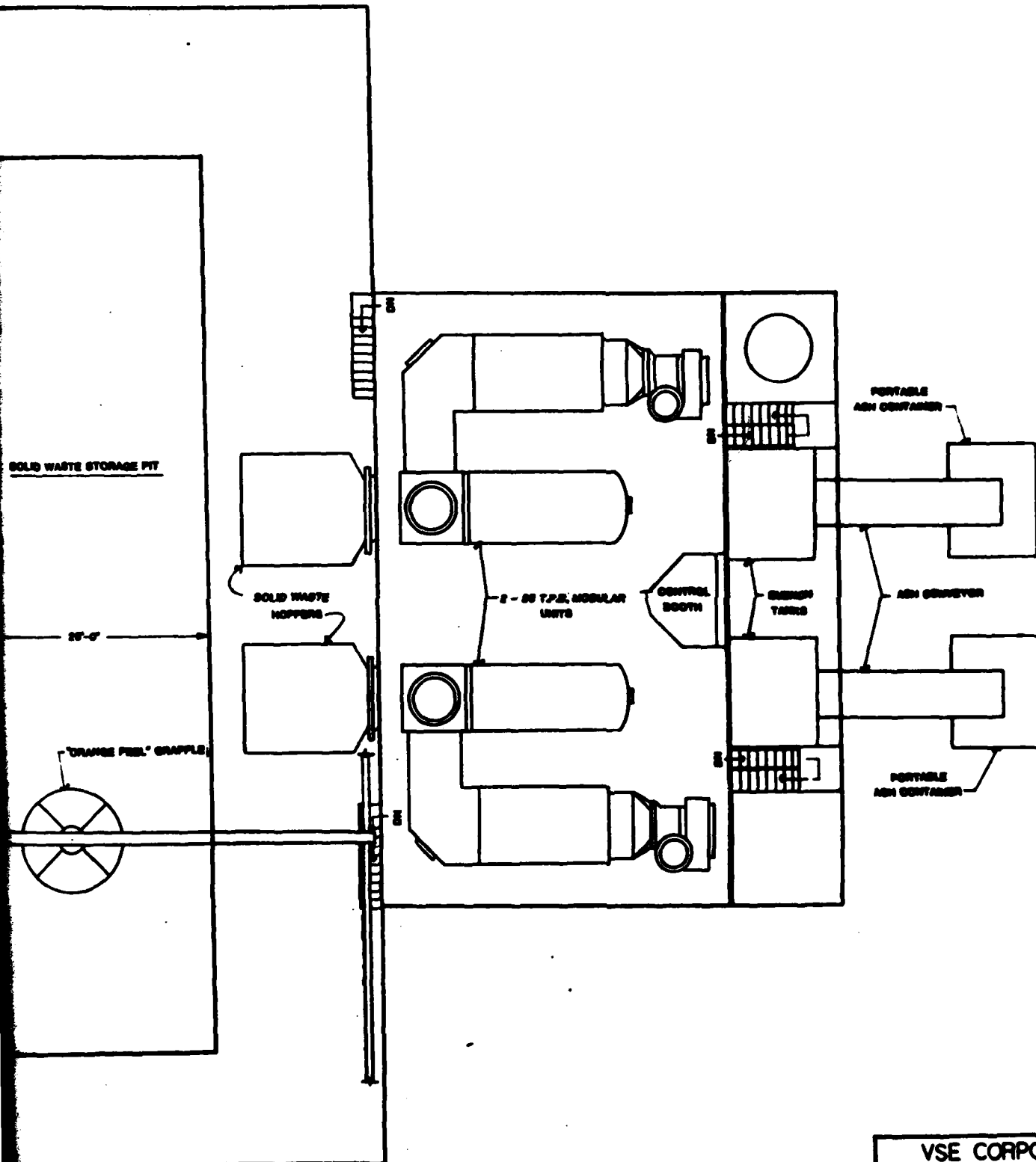
"ORANGE PEEL" GRAPPLE

TROLLEY CRANE

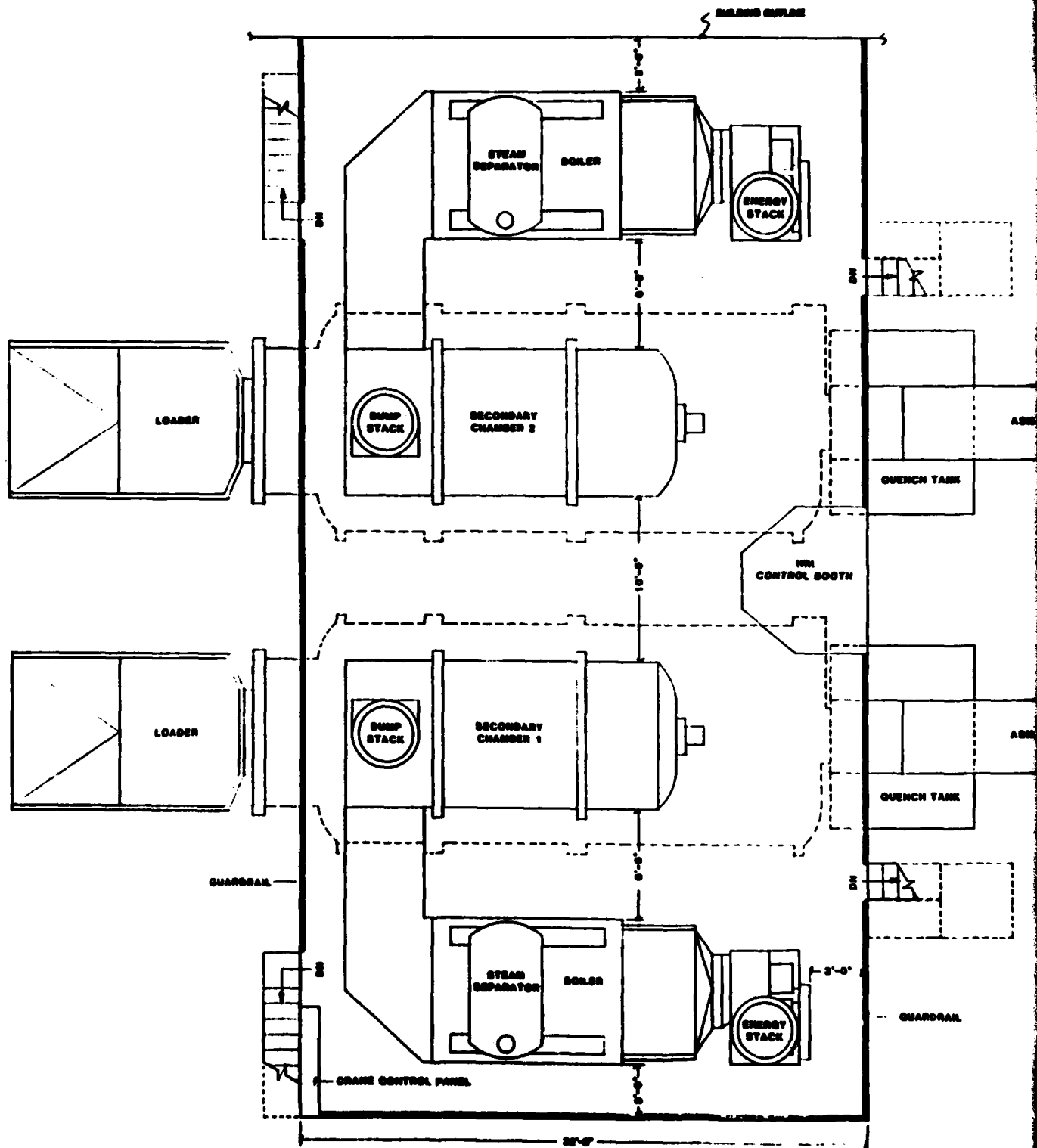
SOLID WASTE
HOPPER

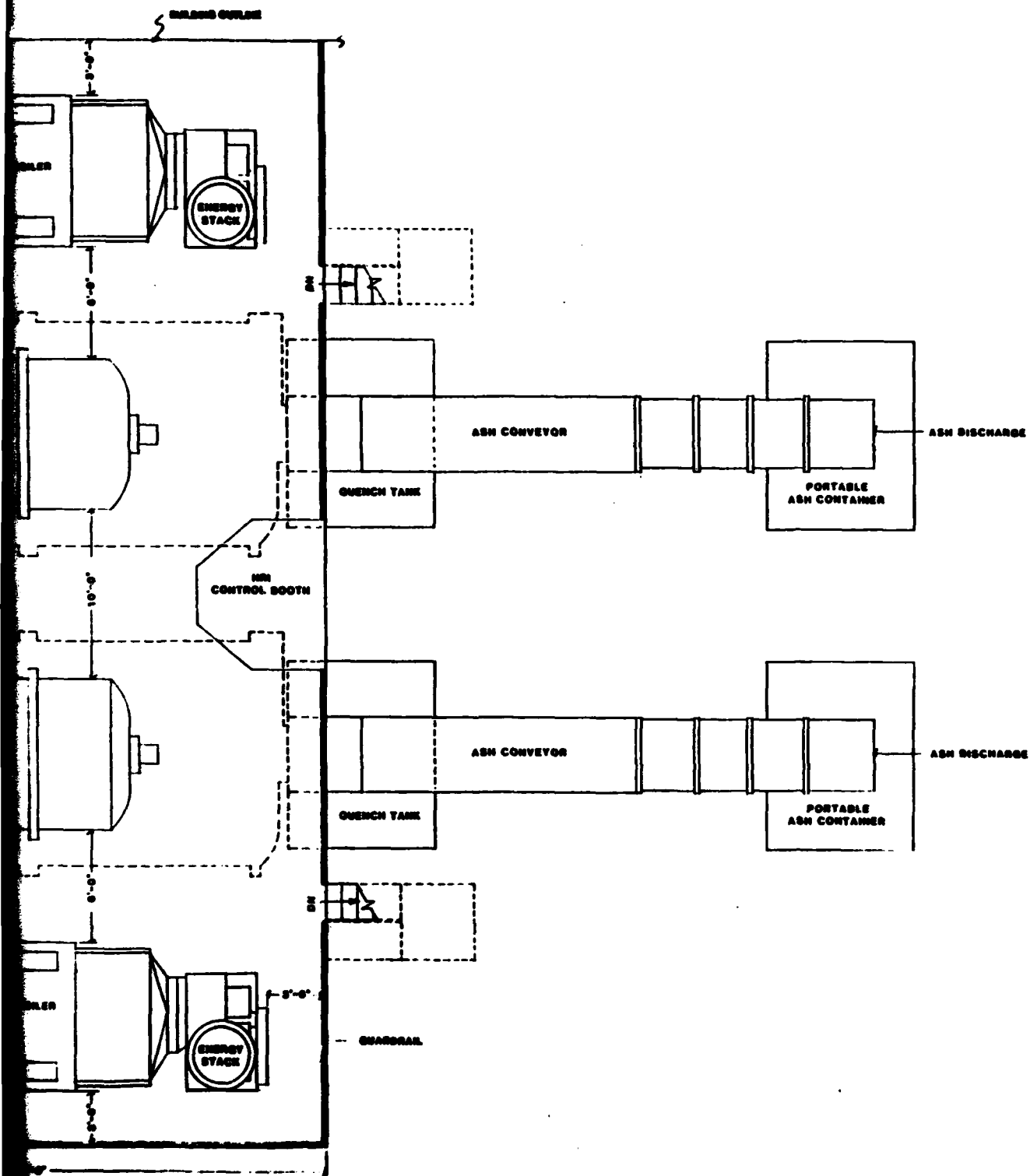
TRUCK EXIT



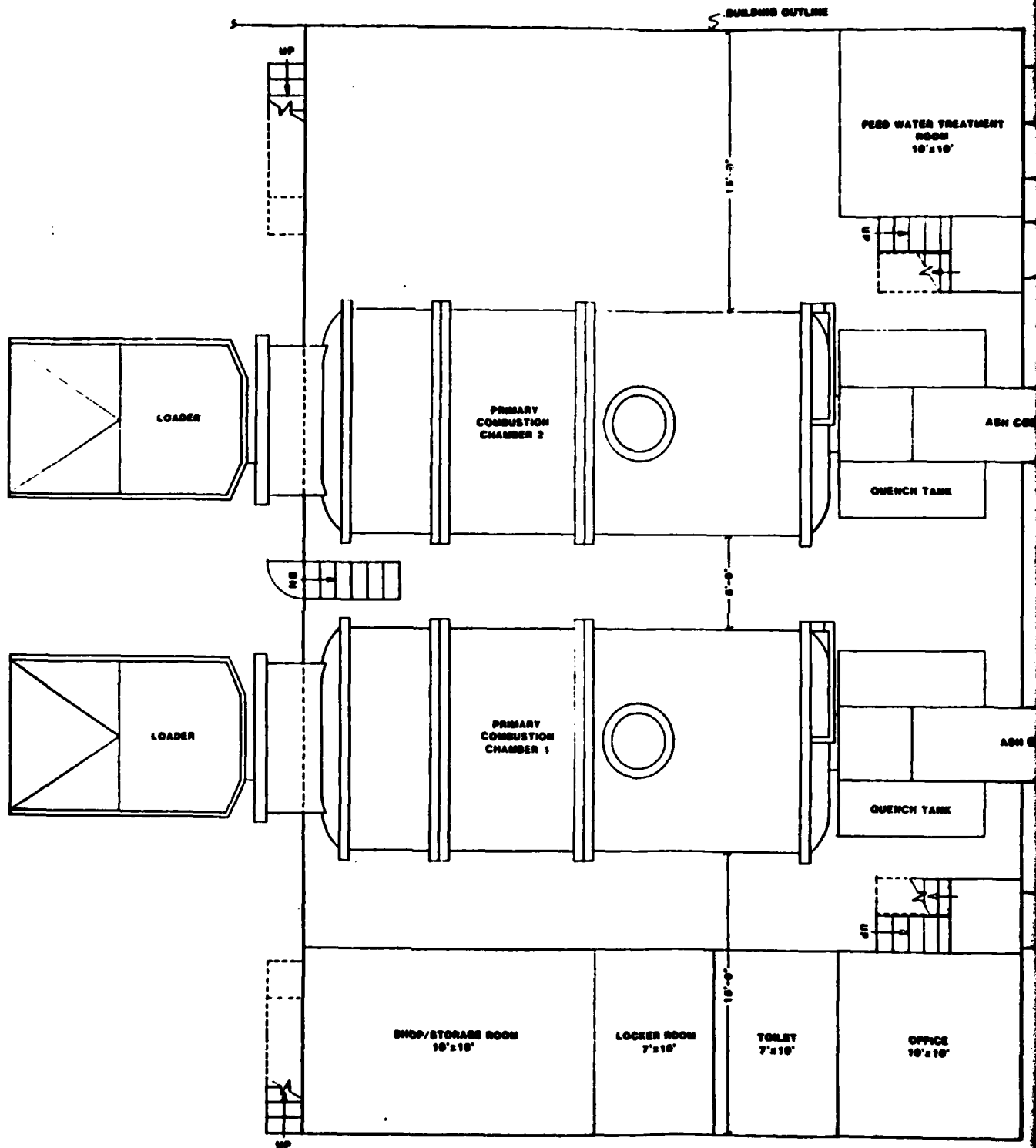


VSE CORPORATION ORLAND, CA.
HEAT RECOVERY INCINERATOR FIGURE 2 ALTERNATE PLANT LAYOUT
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VSE CORPORATION ORLAND, CA
HEAT RECOVERY INCINERATOR FIGURE 3
UPPER LEVEL MECHANICAL AREA FLOOR PLAN
0/02



BUILDING OUTLINE

FEED WATER TREATMENT
ROOM
10'x10'



ASH CONVEYOR

QUENCH TANK

ASH DISCHARGE

PORTABLE
ASH CONTAINER

ASH CONVEYOR

QUENCH TANK

ASH DISCHARGE

PORTABLE
ASH CONTAINER

LOCKER ROOM
7'x10'

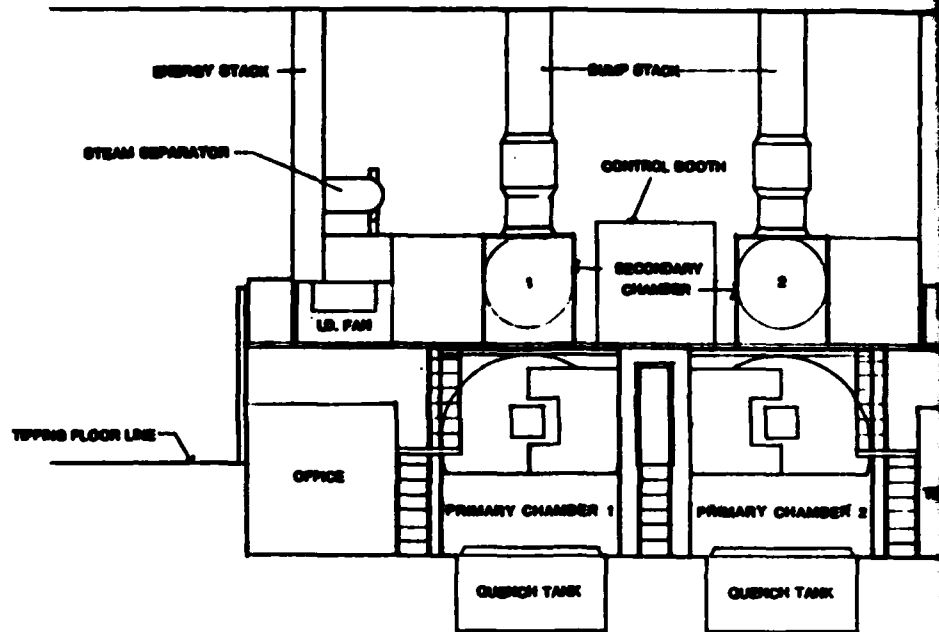
TOILET
7'x10'

OFFICE
10'x10'

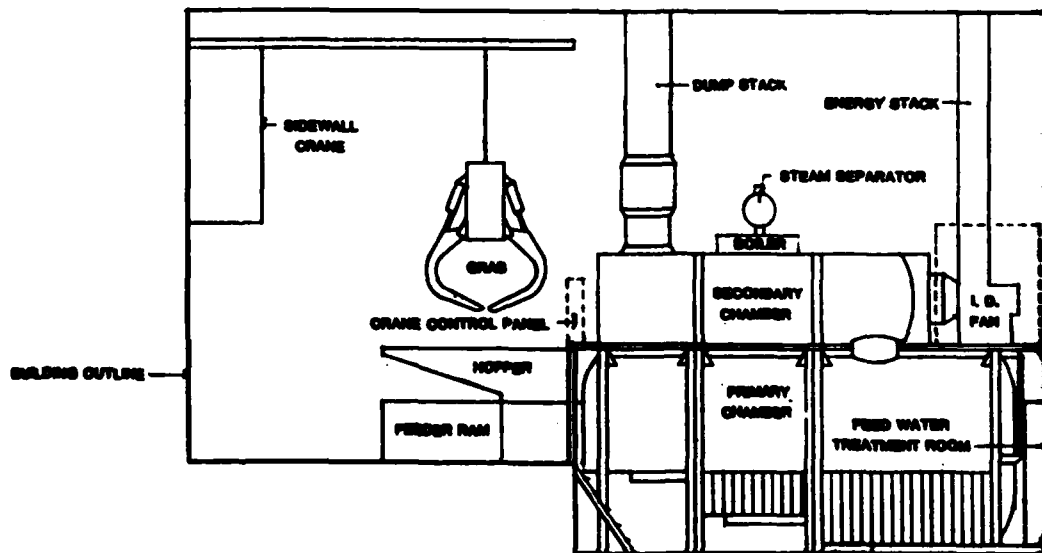


VSE CORPORATION
CHAND, CA
HEAT RECOVERY INCINERATOR
FIGURE 4
LOWER LEVEL MECHANICAL AREA
FLOOR PLAN

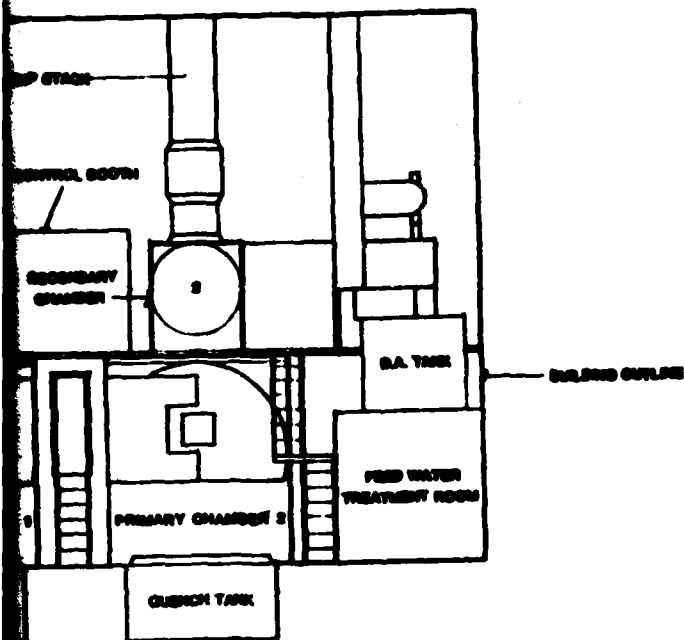
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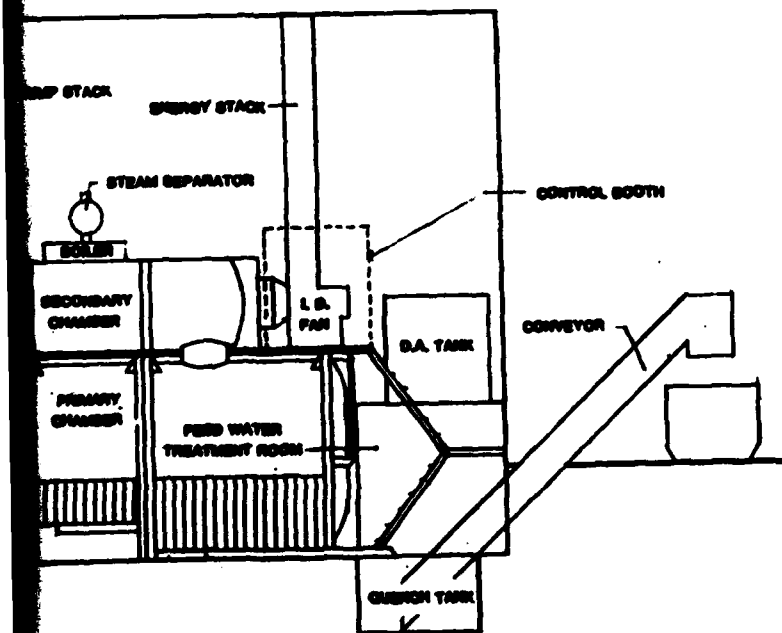
VIEW A - A



VIEW B - B



VIEW A - A



VIEW B - B



VSE CORPORATION ORLAND, CA.
HEAT RECOVERY INCINERATOR FIGURE 5 ELEVATIONS
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